The Anomalous Winter of 2013/2014

- Overview
- Temperature (record Cold)
- Snowfall (record snowfall and snow cover)
- Precipitation (near normal)
- Synoptic Pattern
- Some possible explanations as to why it was so cold

Dec-Jan-Feb Climate Summary

Location		Average Temperature (° F)	Snowfall (inches)
Grand Rapids	Observed	20.7	**105.6**
	Normal	26.8	**57.5**
	Departure	- 6.1	**+ 48.1**
	Rank	**10th Coldest**	**1st**
Lansing	Observed	18.9	**57.3**
	Normal	25.9	**38.4**
	Departure	- 7.0	**+ 18.9**
	Rank	**17th Coldest**	**5th**
Muskegon	Observed	21.8	**114.7**
	Normal	27.6	**76.2**
	Departure	- 5.8	**+ 38.5**
	Rank	**12th Coldest**	**8th**

Ranked in the top 10 percent for cold and snow

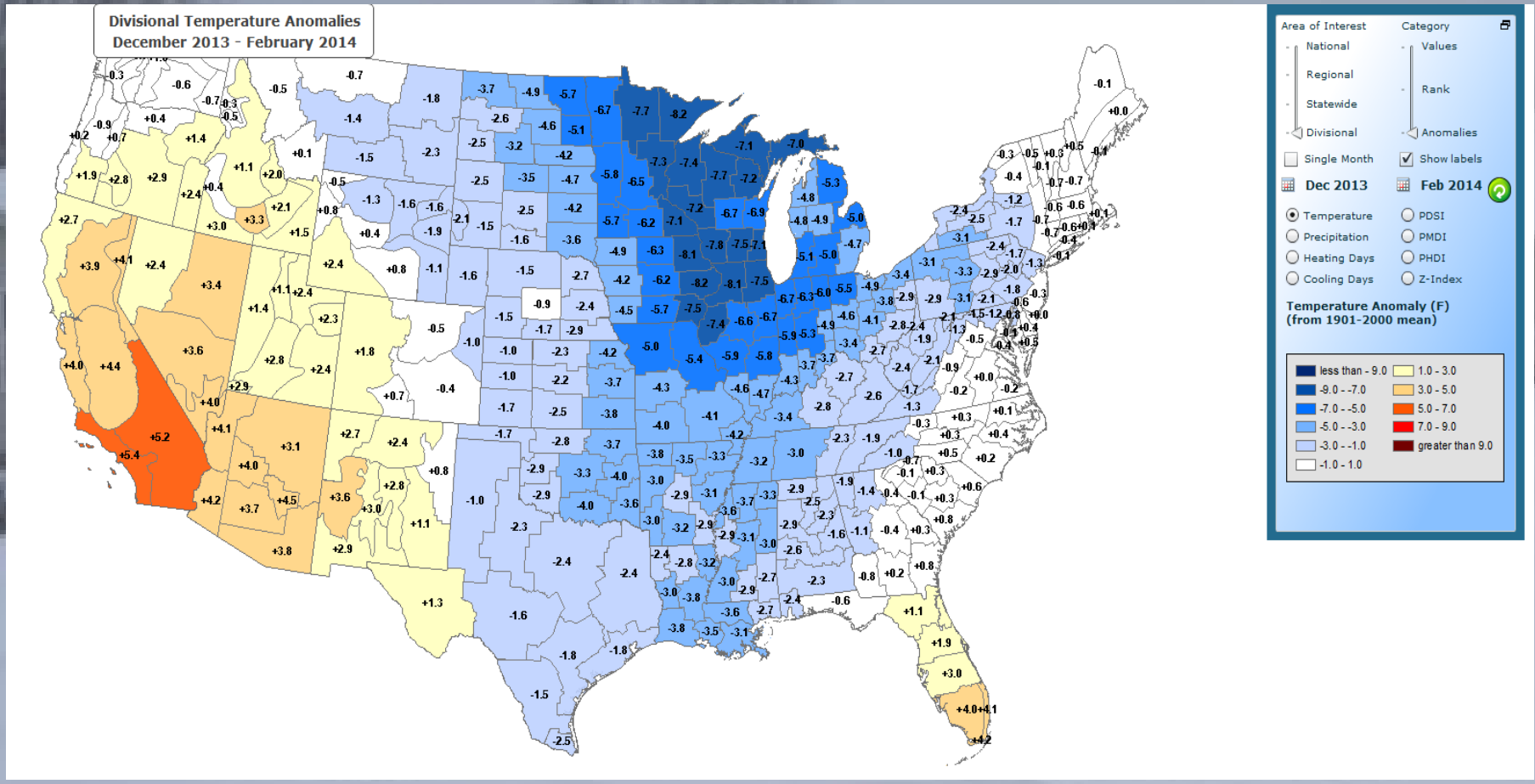
Relentless cold and periodic whiteouts in strong winds

Snow consistently fell with a majority of days recording at least a trace of snow

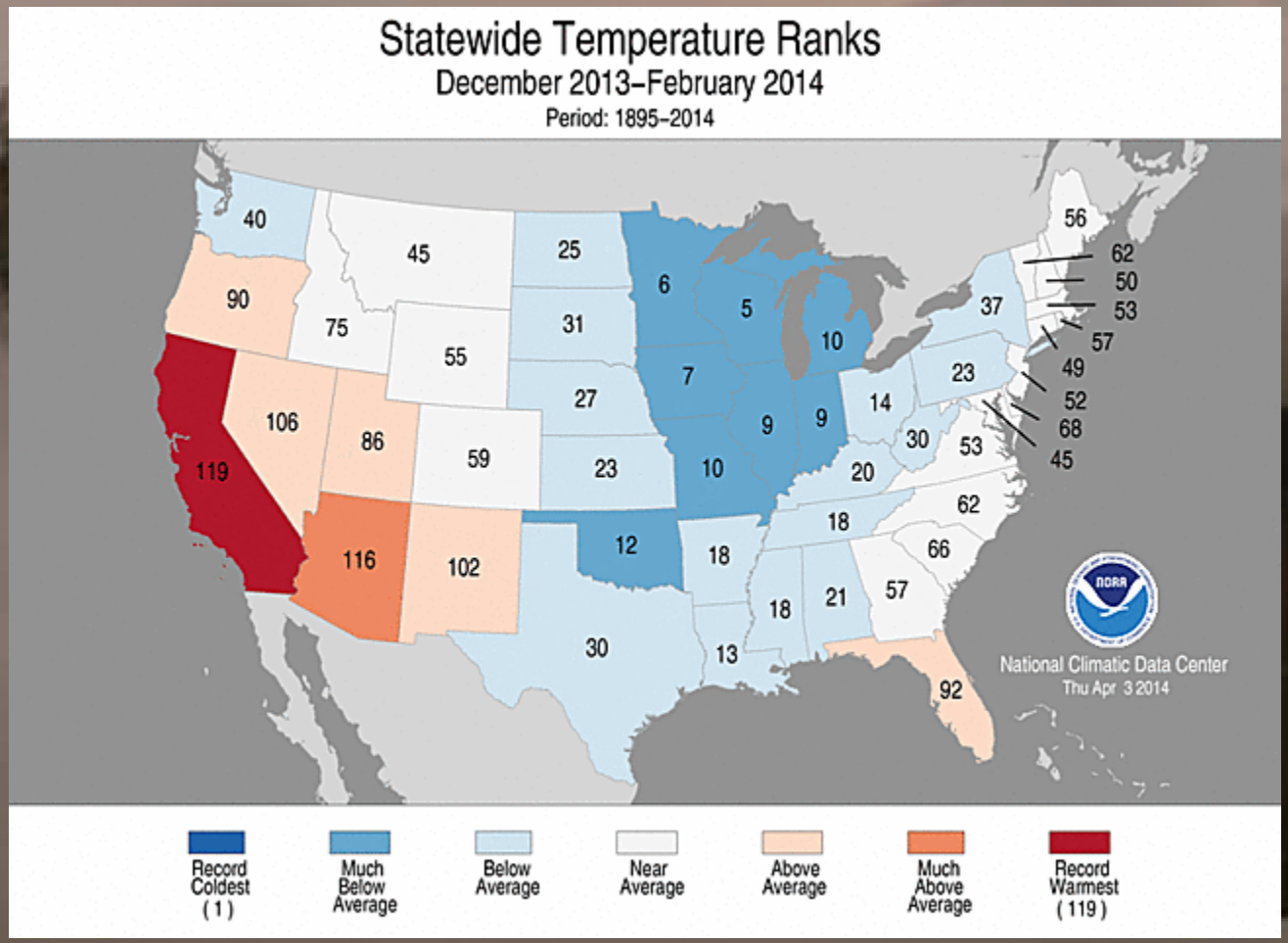
Very persistent and deep snow pack with many snow depth and snowfall records challenged or broken


Record Cold

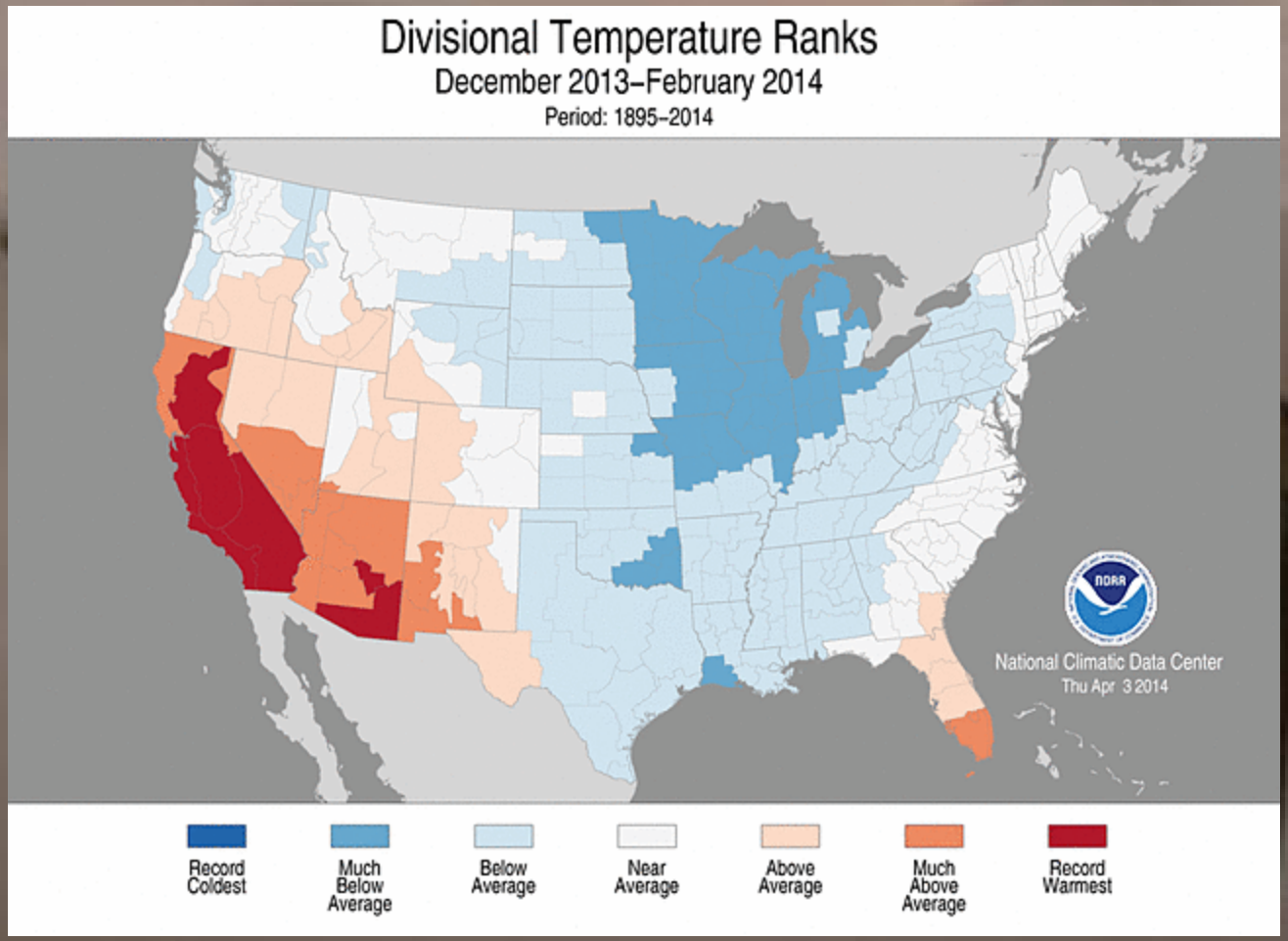
National Temperature Departure from Mean for the Winter of 2013/2014



State Temperature Ranking for the Winter of 2013/2014



Climate Division Temperature Ranking for the Winter of 2013/2014

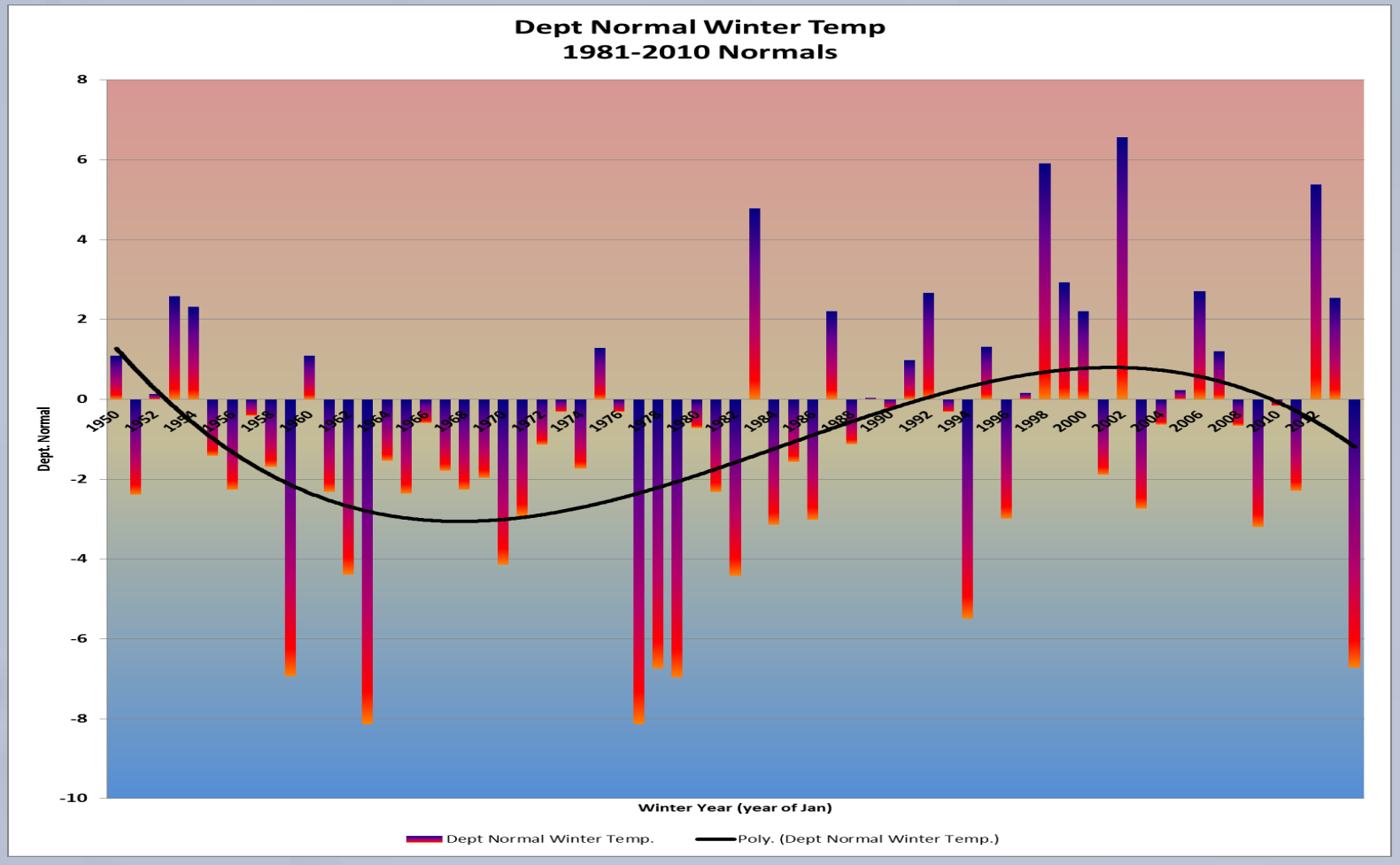


Southwest Lower Michigan Winter Temperature Ranking

Group Average				Dep.
Rank	**Rank**	**Year ***	Data	1981-2010
1	119	1904	13.6	-11.4
2	118	1918	15.5	-9.4
3	117	1920	16.0	-8.9
4	116	1963	16.8	-8.1
5	115	1977	16.8	-8.1
6	114	1905	16.9	-8.0
7	113	1936	17.1	-7.9
8	112	1912	17.4	-7.5
9	111	1917	17.9	-7.0
10	110	1979	18.0	-7.0
11	109	1959	18.0	-6.9
12	108	1978	18.2	-6.7
13	107	2014	18.2	-6.7
14	106	1899	18.4	-6.5
15	105	1994	19.5	-5.5
16	104	1901	20.3	-4.6
17	103	1910	20.3	-4.6
18	102	1945	20.4	-4.5
19	101	1902	20.5	-4.5
20	100	1929	20.5	-4.5

Area Mean Rank for Dec- Feb 1896-2014

Just How Unusual Was the Temperature This Winter



Graph of area means for all winters from 1950/1951 through 2013/2014

An Unusually Cold Winter

2013-2014 WINTER (DEC 01 > FEB 28) Winter Mean Temperature						
LOCATION	Mean Temp.	Normal	Departure	Rank	Record	YEAR
GRR	20.7	26.8	-6.1	10	18.0	1977
LAN	18.9	25.9	-7.0	17	13.7	1875
MKG	21.8	27.6	-5.8	12	18.1	1904

Unusually Frequent Highs Below Freezing

2013-2014 WINTER (DEC 01 > FEB 28) Number of Days Highs <=32						
LOCATION	# of Days	Normal	Departure	Rank	Record	YEAR
GRR	66	41	25	6	70	1978/1920
LAN	69	46	23	6	74	1920
MKG	64	40	24	5	72	1978

2013-2014 SEASON (July 1 > June 30) Number of Days Highs <=32						
LOCATION	# of Days	Normal	Depature	Rank	Record	YEAR
GRR	83	44	39	4	90	1904
LAN	88	55	33	3	96	1904
MKG	80	46	34	4	88	1904

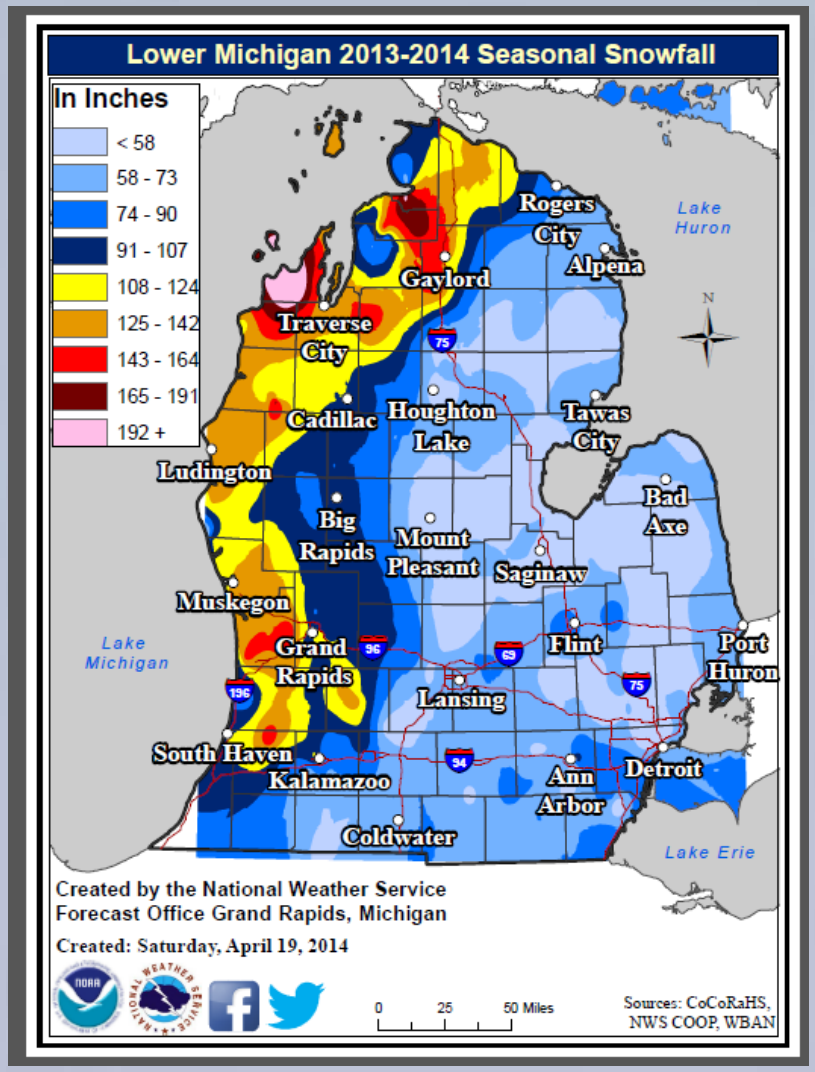
Unusually Frequent Lows Below Freezing

2013-2014 WINTER (DEC 01 > FEB 28) Number of Days Lows <=32						
LOCATION	# of Days	Normal	Departure	Rank	Record	YEAR
GRR	86	77	9	22	91	1920
LAN	88	77	11	25	91	1920/1888
MKG	86	75	11	17	90	1959/45/20/04

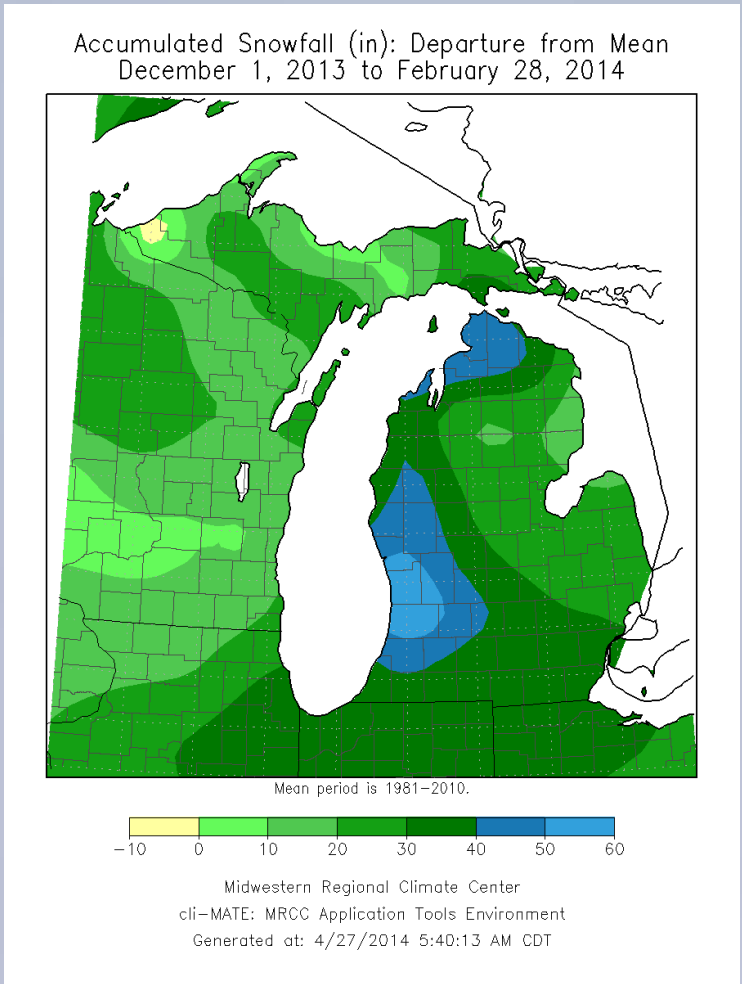
2013-2014 SEASON (July 1 > June 30) Number of Days Lows <=32						
LOCATION	# of Days	Normal	Departure	Rank	Record	YEAR
GRR	141	126	15	56	165	1975
LAN	152	131	21	75	216	1869
MKG	138	123	15	56	166	1996


Record Snows and
Snow Cover

Lower Michigan Snowfall for the Winter of 2013/2014



Michigan Snowfall Departure from Normal for the Winter of 2013/2014



RECORD SNOWS

2013-2014 WINTER SNOWFALL (DEC 01 > FEB 28)						
LOCATION	Snowfall (inches)	Normal (inches)	Depature (inches)	Rank	SNOWIEST	YEAR
GRR	105.6	57.5	48.1	1	105.6	2014
LAN	57.3	38.4	18.9	5	64.2	1908
MKG	114.7	76.2	38.5	8	140.6	1978

2013-2014 SEASON SNOWFALL (July 1 > June 30)						
LOCATION	Snowfall (inches)	Normal (inches)	Depature (inches)	Rank	SNOWIEST	YEAR
GRR	116.0	74.9	41.1	2	132.0	1952
LAN	69.1	51.1	18.0	16	97.2	1881
MKG	132.7	93.7	39.0	11	173.9	1982

RECORD FREQUENCY FOR MEASURABLE SNOW

2013-2014 WINTER SNOWFALL (DEC 01 > FEB 28) FREQUENCY FOR MEASURABLE SNOW (CALENDER DAY)						
LOCATION	Snowfall (days)	Normal (days)	Depature (days)	Rank	SNOWIEST	YEAR
GRR	61	39	22	1	61	2014
LAN	44	33	11	6	47	1977
MKG	58	39	19	8	60	1977

2013-2014 SEASON (July 1 > June 30) FREQUENCY FOR MEASURABLE SNOW (CALENDER DAY)						
LOCATION	Snowfall (days)	Normal (days)	Depature (days)	Rank	SNOWIEST	YEAR
GRR	75	52	23	2	78	1977
LAN	52	45	7	22	66	1977
MKG	72	52	20	8	80	1977

RECORD FREQUENCY FOR 1" SNOWFALLS

2013-2014 WINTER SNOWFALL (DEC 01 > FEB 28) FREQUENCY FOR 1" SNOW (CALENDER DAY)						
LOCATION	Snowfall (days)	Normal (days)	Depature (days)	Rank	SNOWIEST	YEAR
GRR	35	18	17	1	35	2014
LAN	17	12	5	8	23	1904
MKG	39	23	16	1	39	2014

2013-2014 SEASON (July 1 > June 30) FREQUENCY FOR 1" SNOW (CALENDER DAY)						
LOCATION	Snowfall (days)	Normal (days)	Depature (days)	Rank	SNOWIEST	YEAR
GRR	40	23	17	1	40	2014
LAN	19	16	3	21	27	1904
MKG	44	32	12	5	50	1965

RECORD FREQUENCY FOR 3" SNOWFALLS

2013-2014 WINTER SNOWFALL (DEC 01 > FEB 28) FREQUENCY FOR 3" SNOW (CALENDER DAY)						
LOCATION	Snowfall (days)	Normal (days)	Depature (days)	Rank	SNOWIEST	YEAR
GRR	12	6	6	2	13	2008
LAN	6	3	3	10	12	1908
MKG	12	9	3	16	19	1994

2013-2014 SEASON (July 1 > June 30) FREQUENCY FOR 3" SNOW (CALENDER DAY)						
LOCATION	Snowfall (days)	Normal (days)	Depature (days)	Rank	SNOWIEST	YEAR
GRR	12	8	4	4	17	1952
LAN	8	4	4	10	13	1908
MKG	14	12	2	8	21	1965

RECORD FREQUENCY FOR 1” SNOW DEPTHS

2013-2014 SEASON FREQUENCY 1" + SNOW DEPTH DAYS						
LOCATION	Snowfall (days)	Normal (days)	Depature (days)	Rank	SNOWIEST	YEAR
GRR	109	68	41	5	124	1904
LAN	107	69	38	3	109	1978
MKG	120	76	44	8	125	1904

RECORD FREQUENCY FOR 3” SNOW DEPTHS

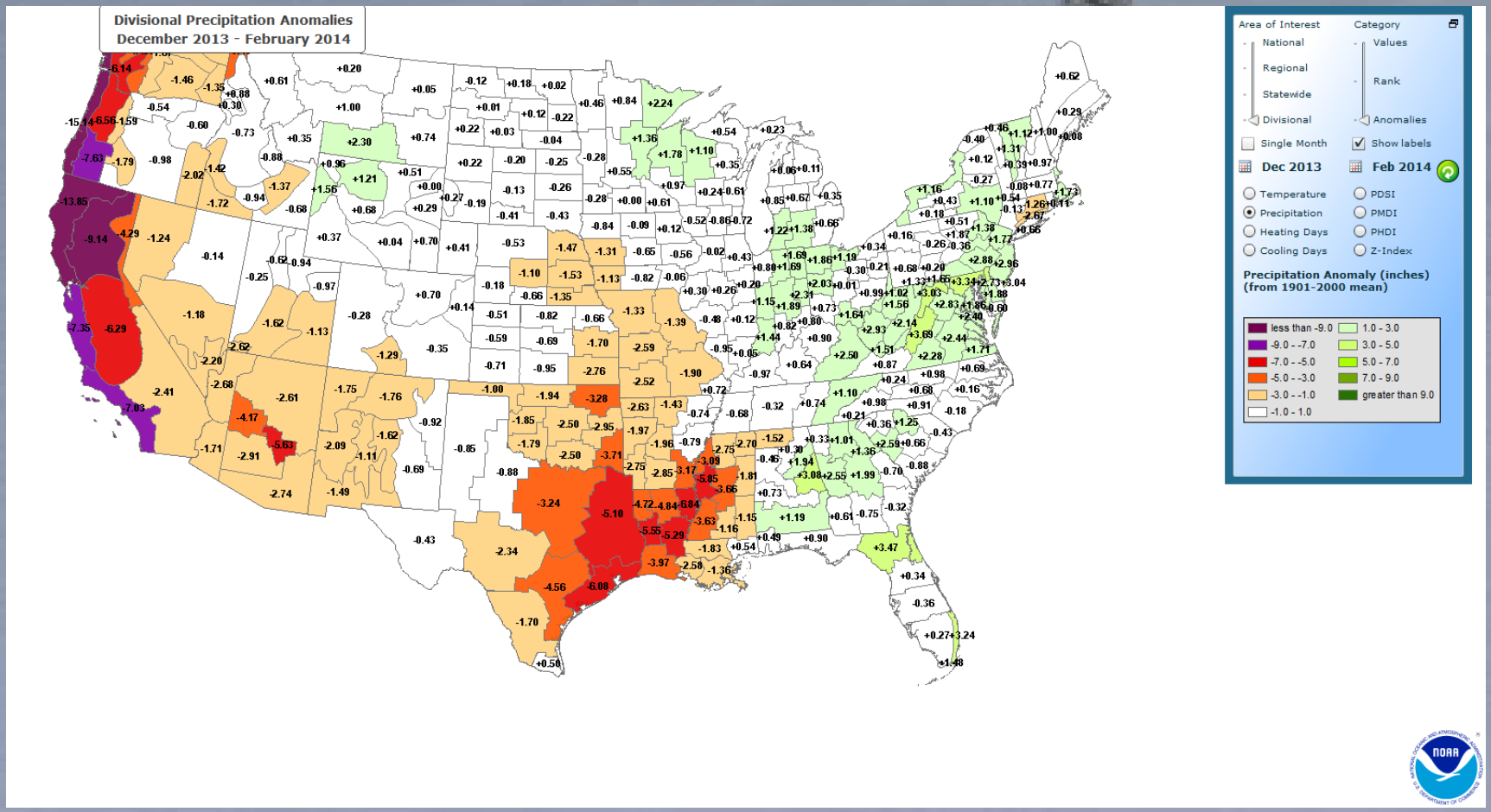
2013-2014 SEASON FREQUENCY 3" + SNOW DEPTH DAYS						
LOCATION	Snowfall (days)	Normal (days)	Depature (days)	Rank	SNOWIEST	YEAR
GRR	103	45	58	3	106	1959 1904
LAN	93	42	51	3	95	1978
MKG	112	55	57	2	118	1904

RECORD CONSECUTIVE DAYS >=1” OF SNOW ON THE GROUND

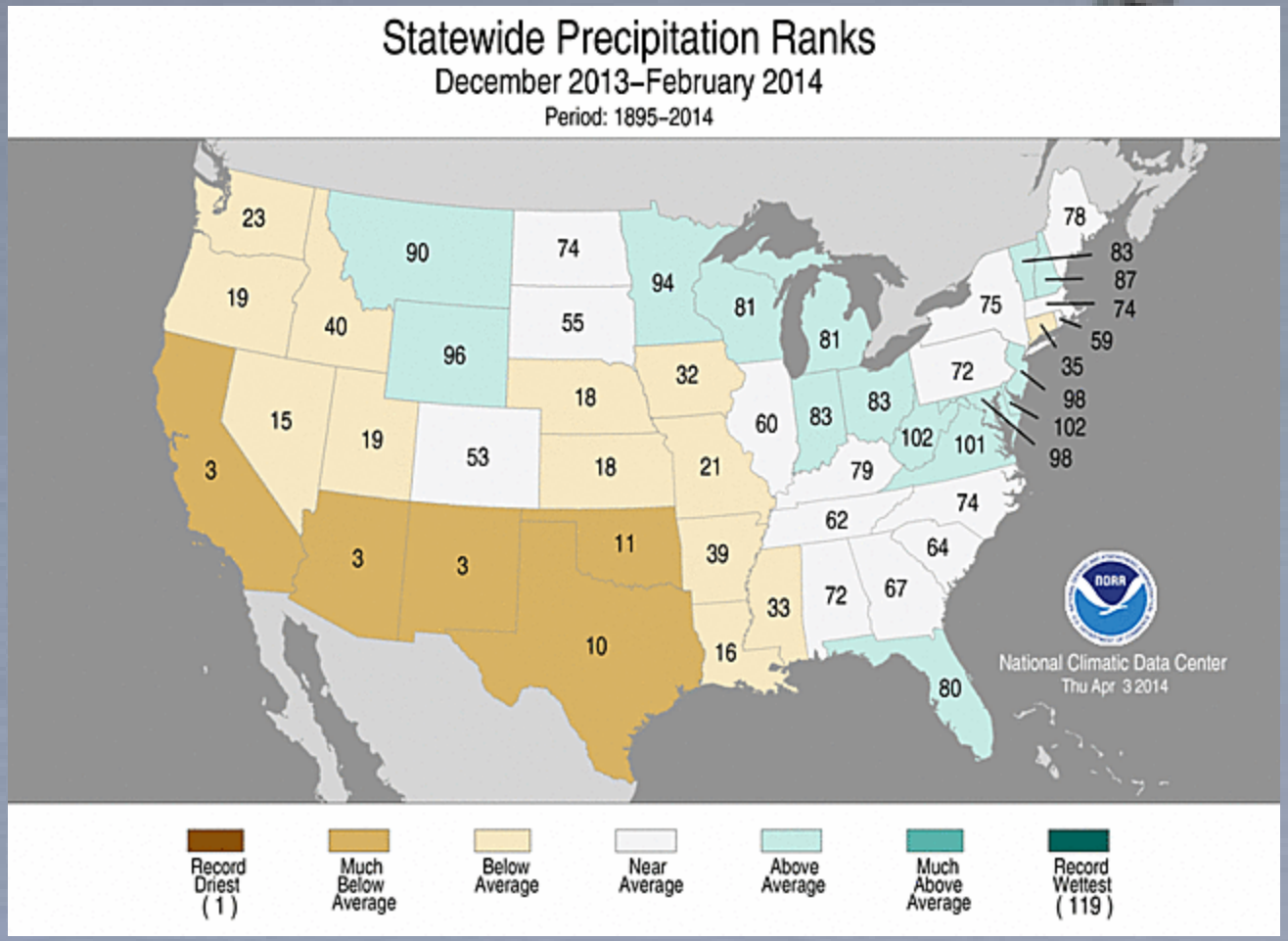
2013-2014 SEASON CONSECUTIVE DAYS SNOW DEPTH >=1"						
LOCATION	Snowfall (days)	Normal (days)	Depature (days)	Rank	SNOWIEST	YEAR
GRR	105	38	67	2	107	1979
LAN	106	36	70	1	106	2014
MKG	113	45	68	2	118	1904


Precipitation Was
Near Normal

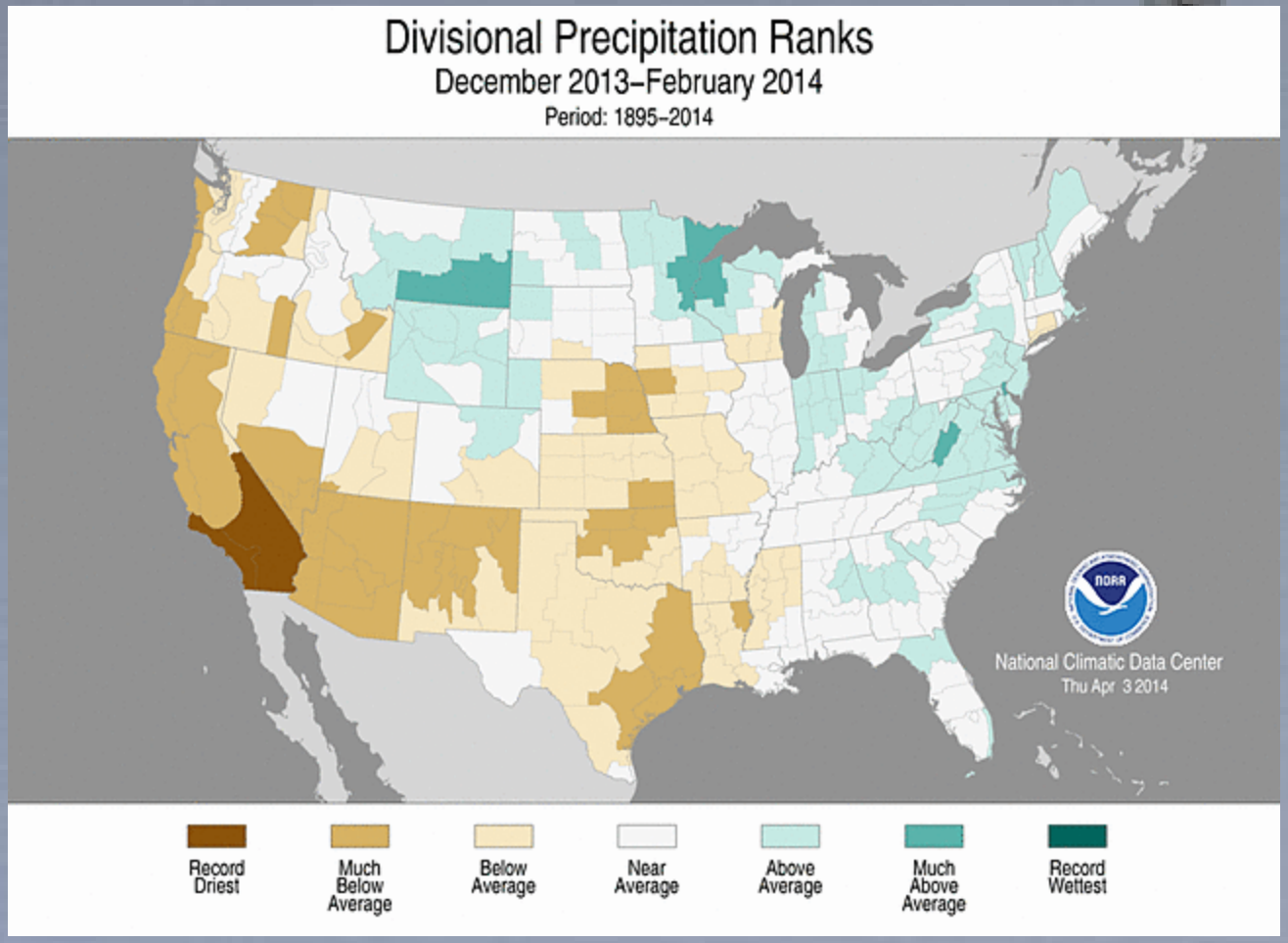
National Precipitation Departure from Mean for the Winter of 2013/2014



State Precipitation Ranking for the Winter of 2013/2014



Climate Division Precipitation Ranking for the Winter of 2013/2014

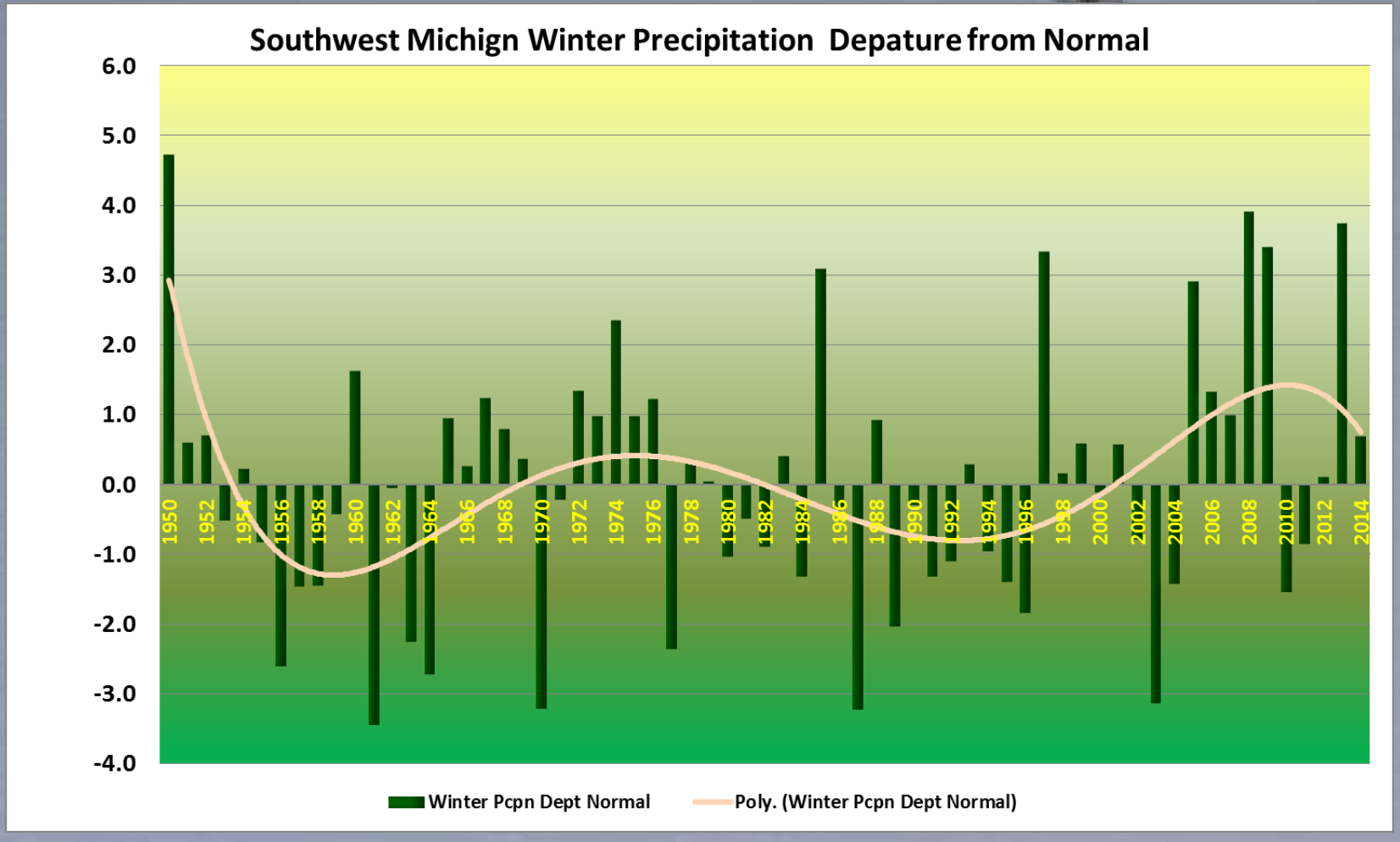


Just How Unusual Was the Precipitation This Winter

Wet Rank	Dry Rank	Data	k Year	Dept
97	29	4.64	1995	-1.38
106	21	4.19	1996	-1.83
7	115	9.37	1997	3.35
53	70	6.20	1998	0.18
37	85	6.62	1999	0.60
61	63	5.92	2000	-0.10
38	84	6.61	2001	0.59
76	49	5.24	2002	-0.78
123	5	2.90	2003	-3.12
98	28	4.61	2004	-1.41
9	113	8.94	2005	2.92
18	104	7.36	2006	1.34
24	97	7.02	2007	1.00
4	118	9.93	2008	3.91
6	116	9.43	2009	3.41
101	25	4.50	2010	-1.53
79	45	5.18	2011	-0.84
54	69	6.15	2012	0.12
5	117	9.77	2013	3.75
34	88	6.72	2014	0.70

Area Mean Rank for Dec- Feb 1896-2014

Area Mean Winter Precipitation 1950-2014

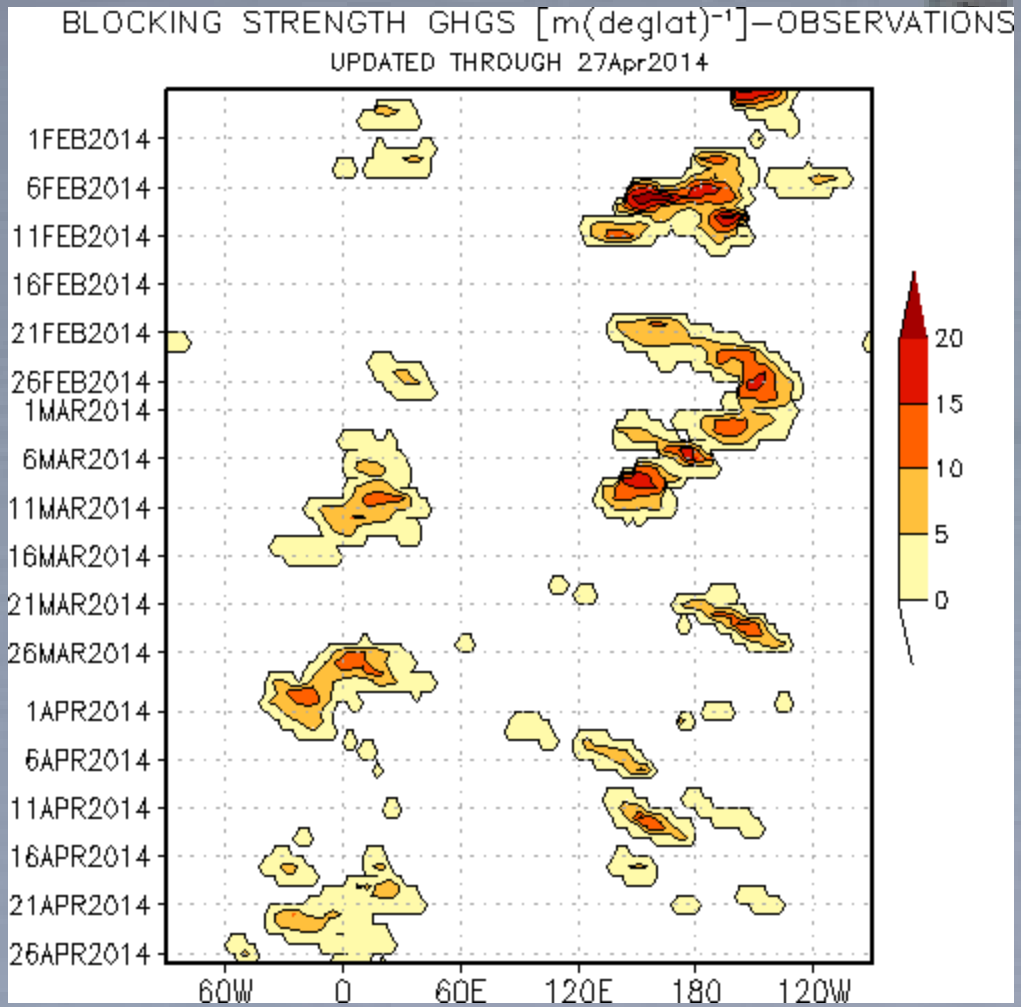


What Caused this Cold Winter

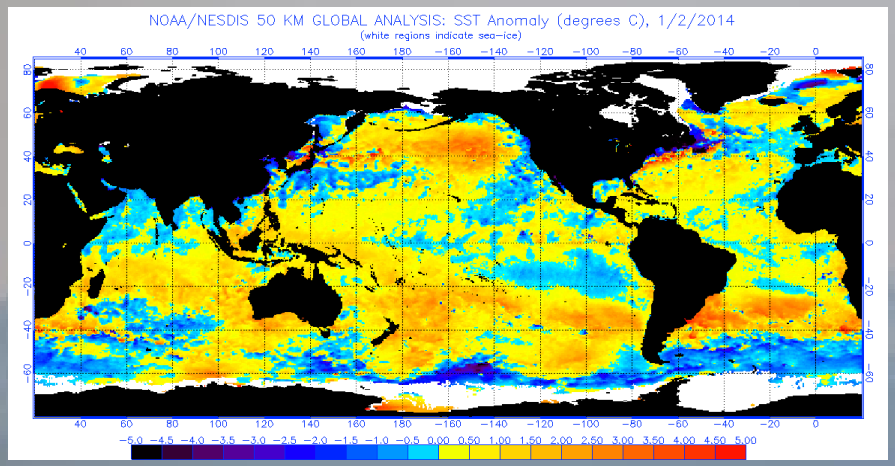
Blocking was the primary problem but what caused the blocking?

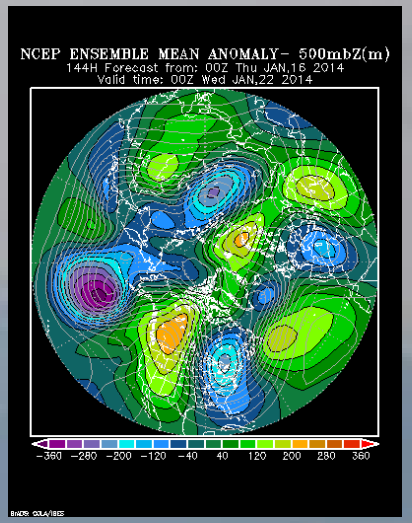
- **Warm Water in the Gulf of Alaska**
- **Snow cover Anomaly over Eastern Asia**
- **ENSO convection staying west of Dateline**
- **Sudden Stratospheric warming events**
- **Solar Cycle weaker**

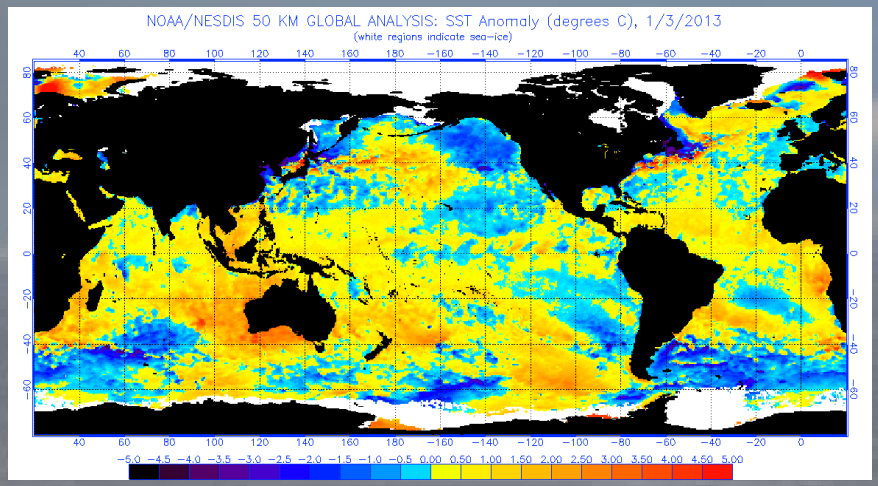
Blocking Was The Primary Problem



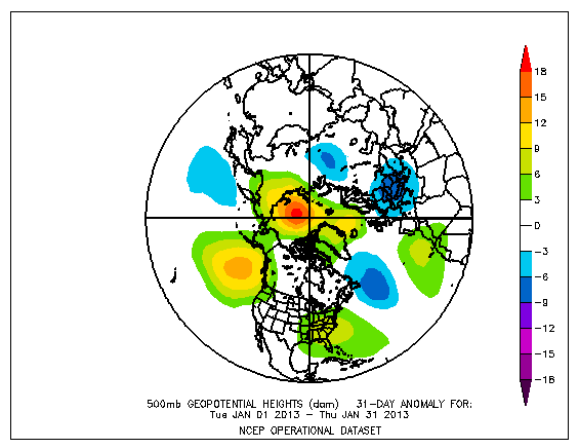
Warm Water In Gulf of Alaska

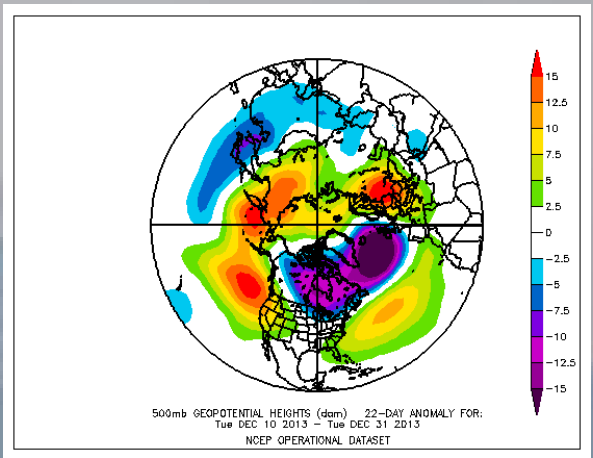


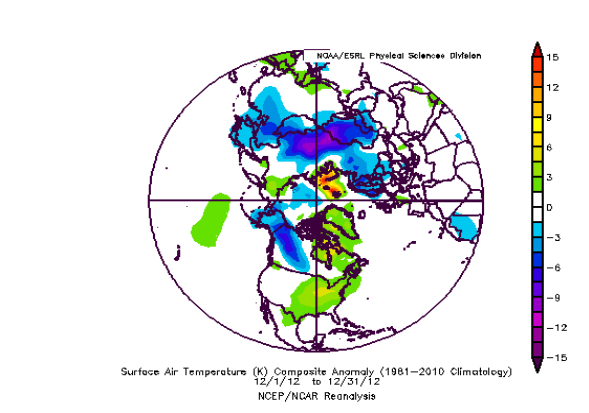


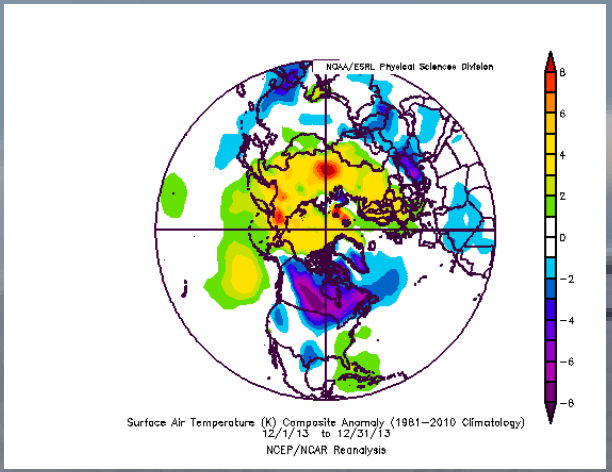


Compare Upper Level / Surface 2012/2013 to 2013/2014

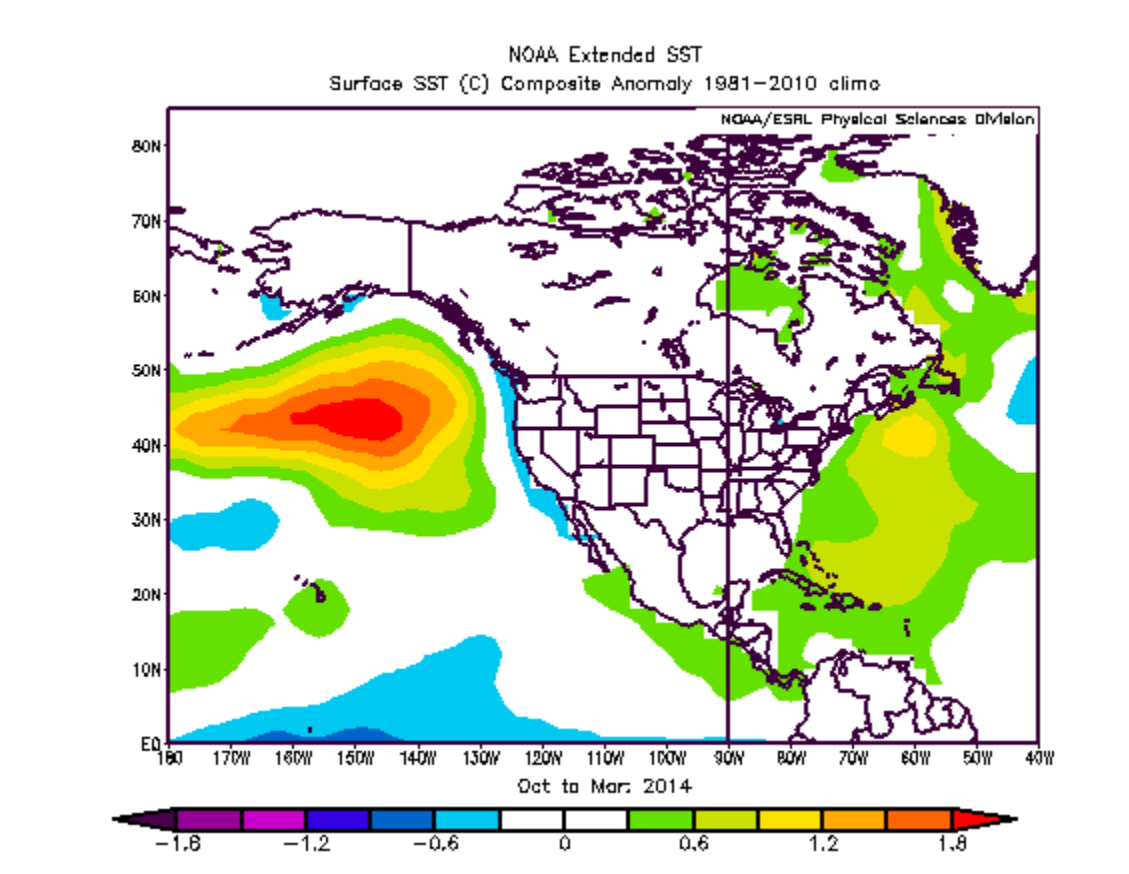




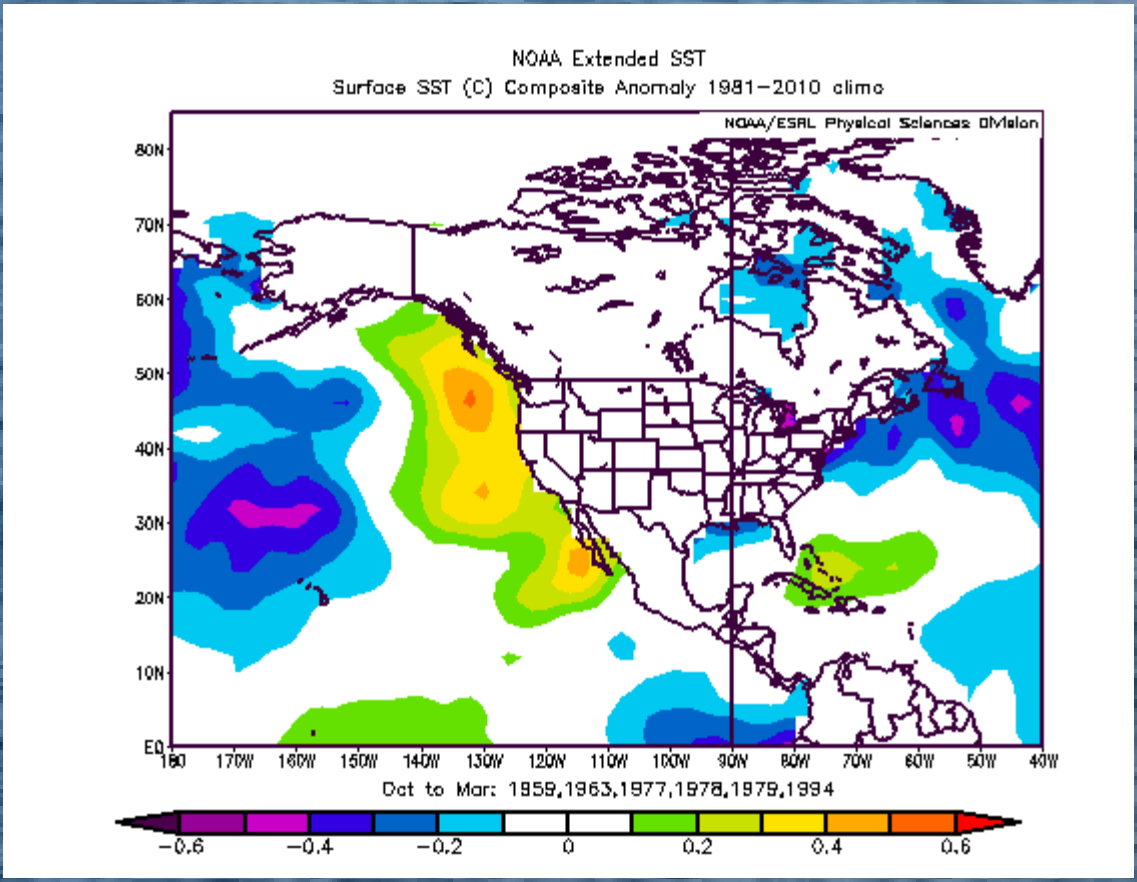




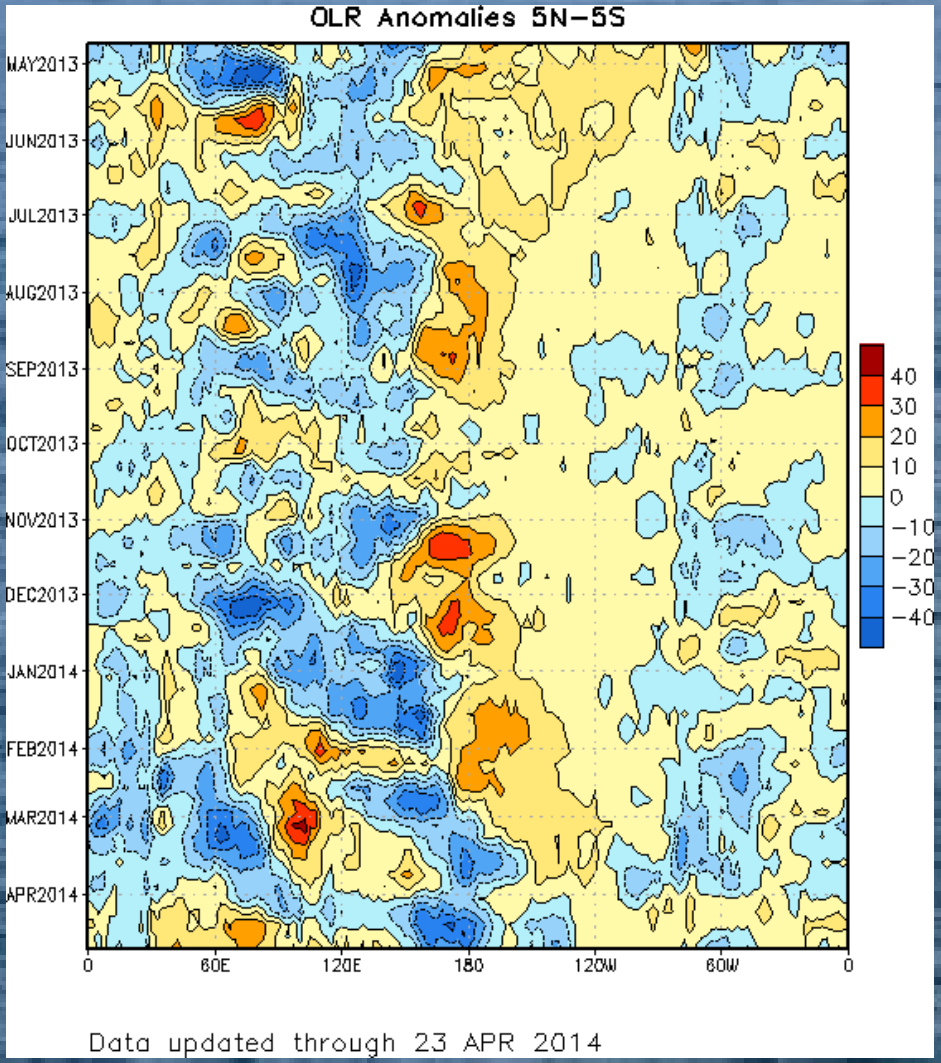
Warm Water Gulf of Alaska



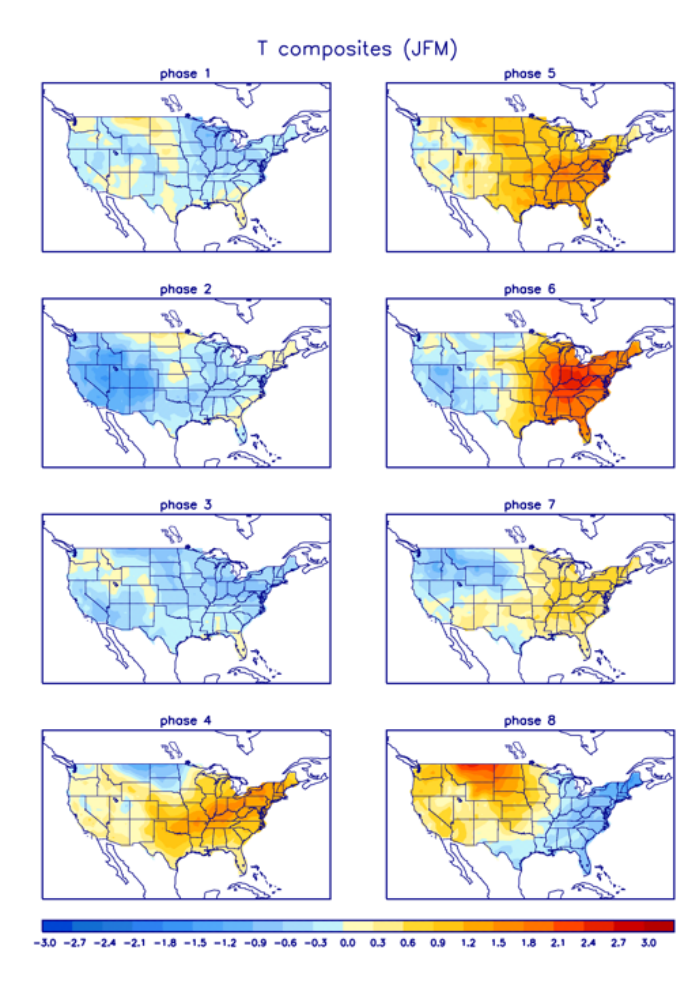
Sea Surface Temperature Anomalies for all winters since 1951 that were more then 5F below normal

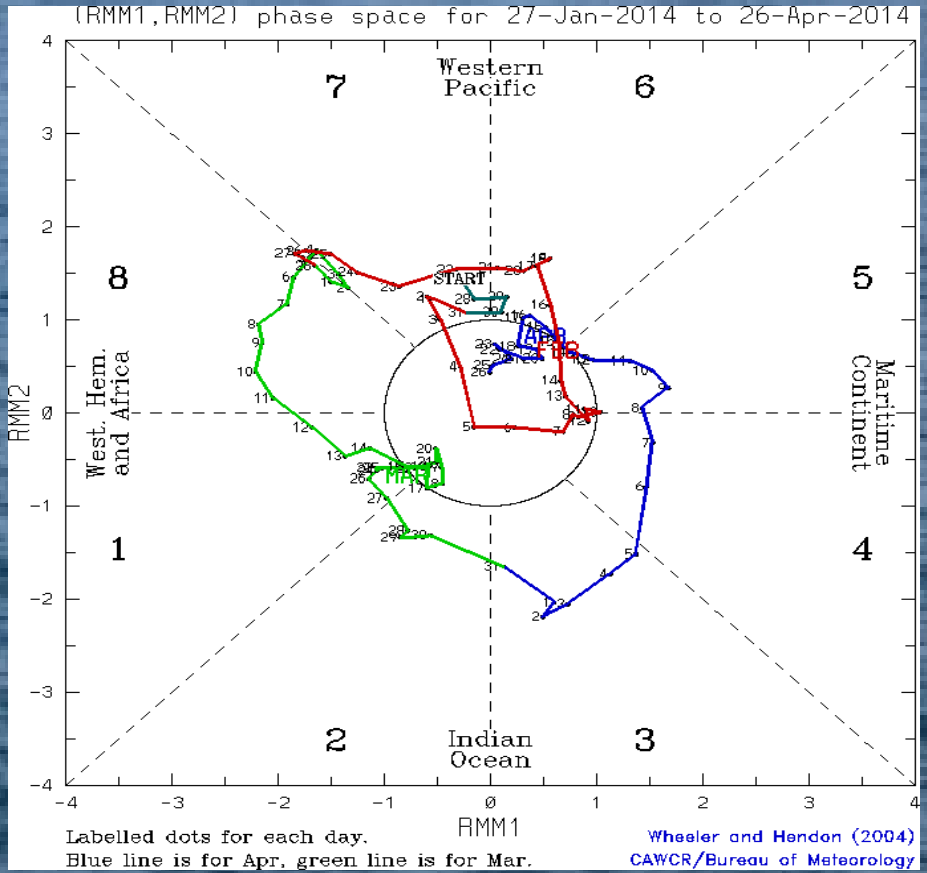


Convection Stayed west of Dateline

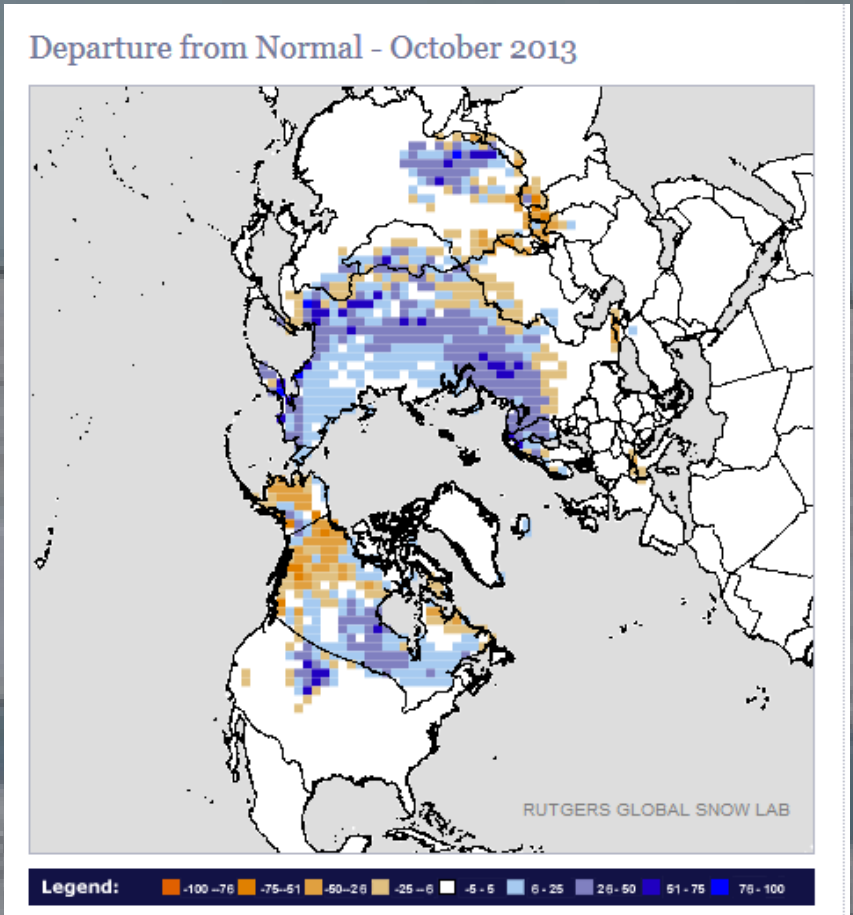


Convection East of Dateline brings cold weather to central and eastern U. S.



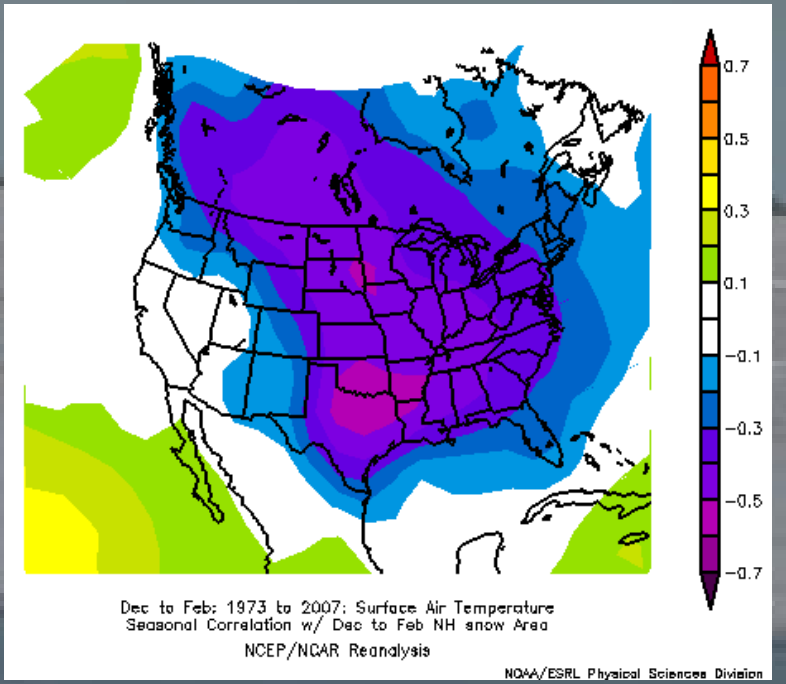


October 2013 Snow Cover Departure From Normal



The EASCA for October 2013 was 2.88 million sq. km above normal, that is the 3rd highest on record (since 1968) .

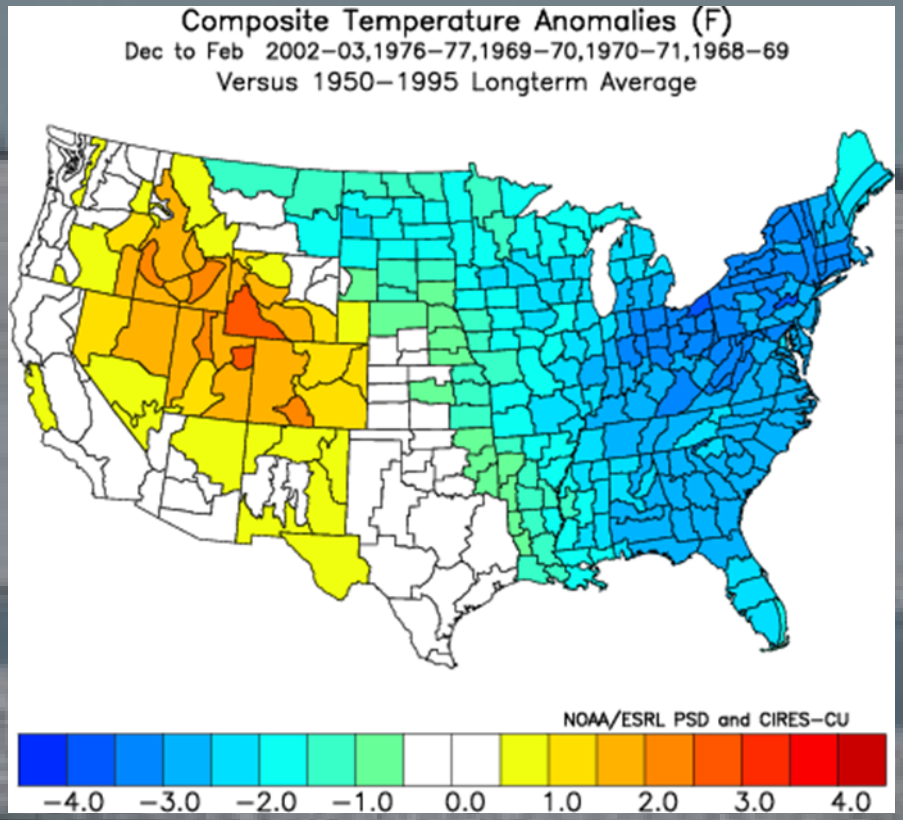
October East Asian Snow Cover Anomaly Implications

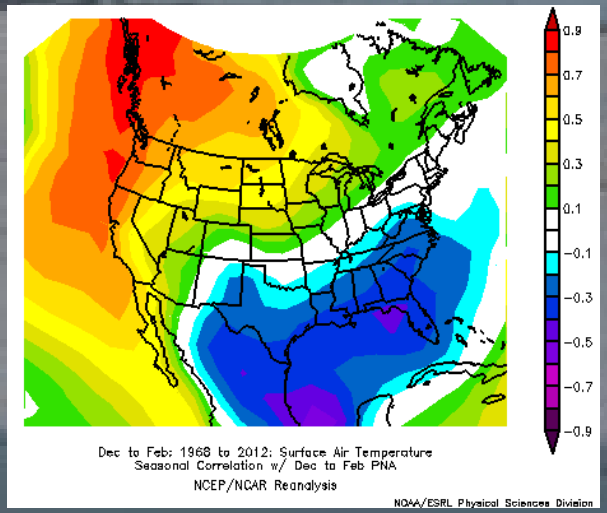


The Correlation of the Northern Hemisphere snow cover anomaly to the CONUS winter temperatures is strong and negative. This suggests a positive snow cover anomaly would mean a colder than normal winter, and visa-versa Note that for an anomaly to be statistically significant the value has to exceed ±0.3

Winter 2013-14

When the East Asian Snow Cover (EASC) Anomaly for October is more than 2.1 million sq. km above normal (1 standard deviation) the resulting winter temperature pattern looks like a positive PNA pattern for CONUS.



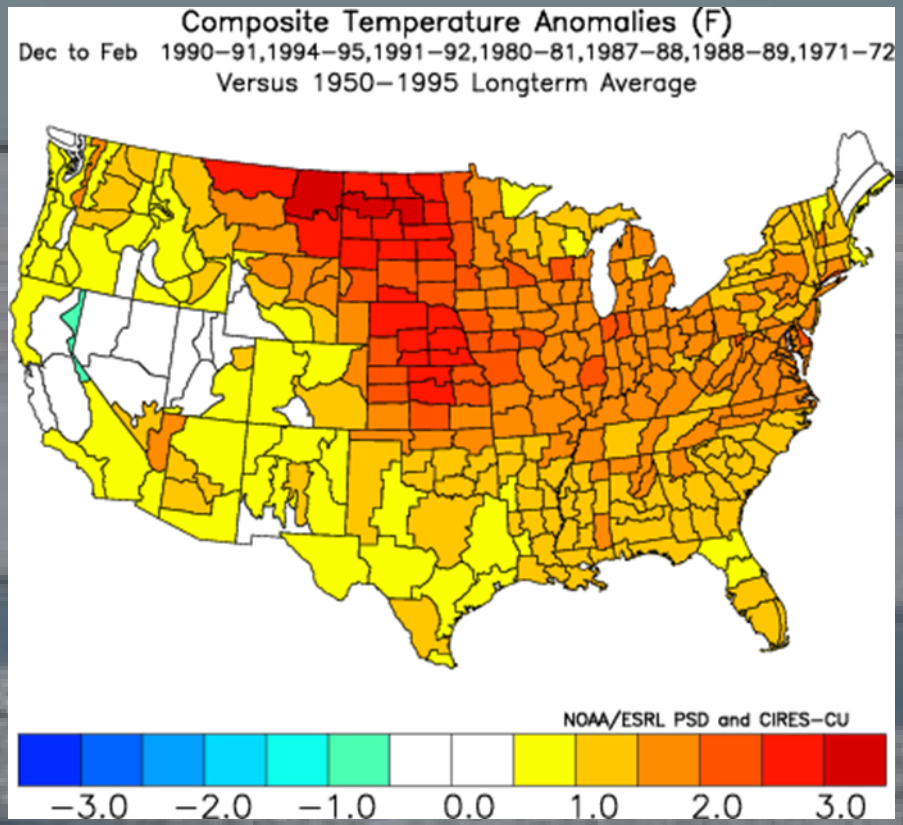


Temperature anomaly for above normal East Asian snow cover puts Southwest Michigan around 3.0 degrees below normal.

Temperature Correlation for a Positive PNA

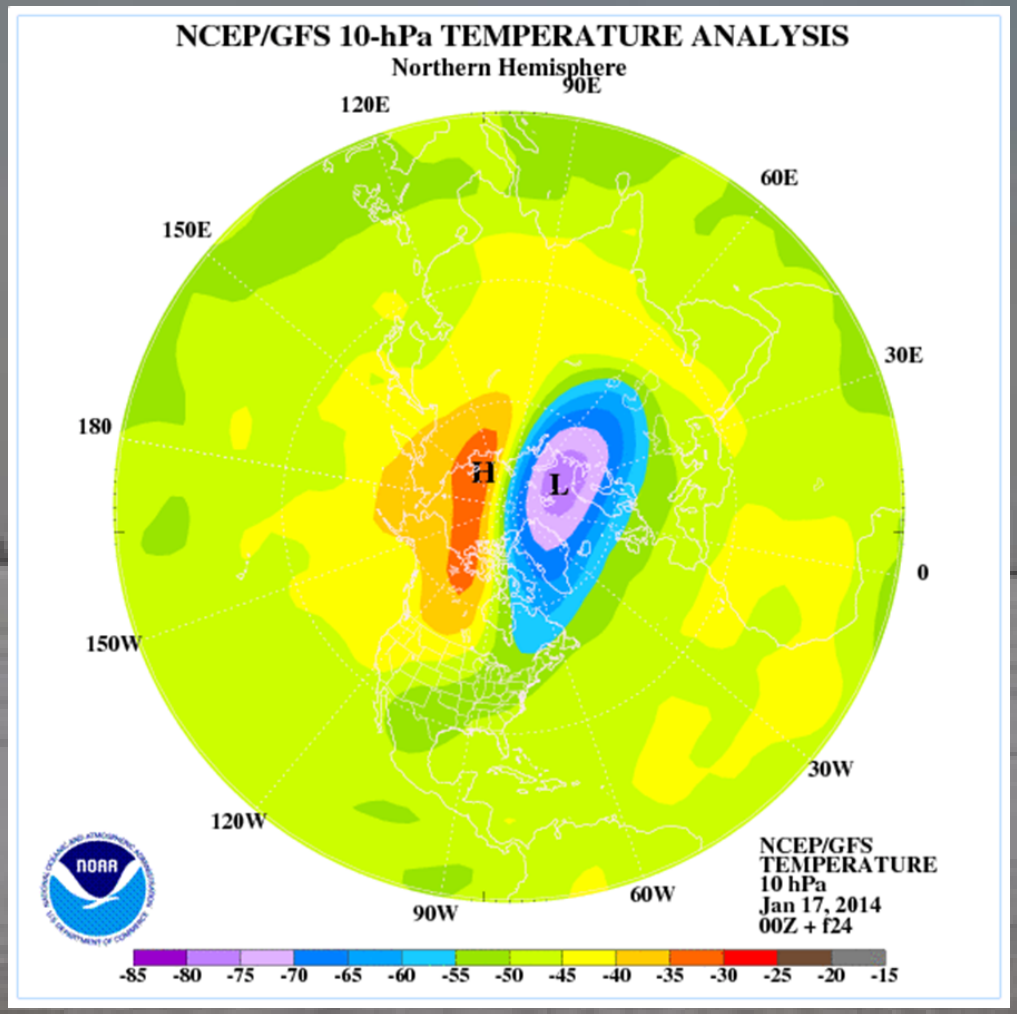
Winter 2013-14

When The East Asian Snow Cover anomaly in October is more than 2.1 million sq. km below normal (1 standard deviation) the resulting winter temperature pattern looks like a negative PNA pattern for CONUS.

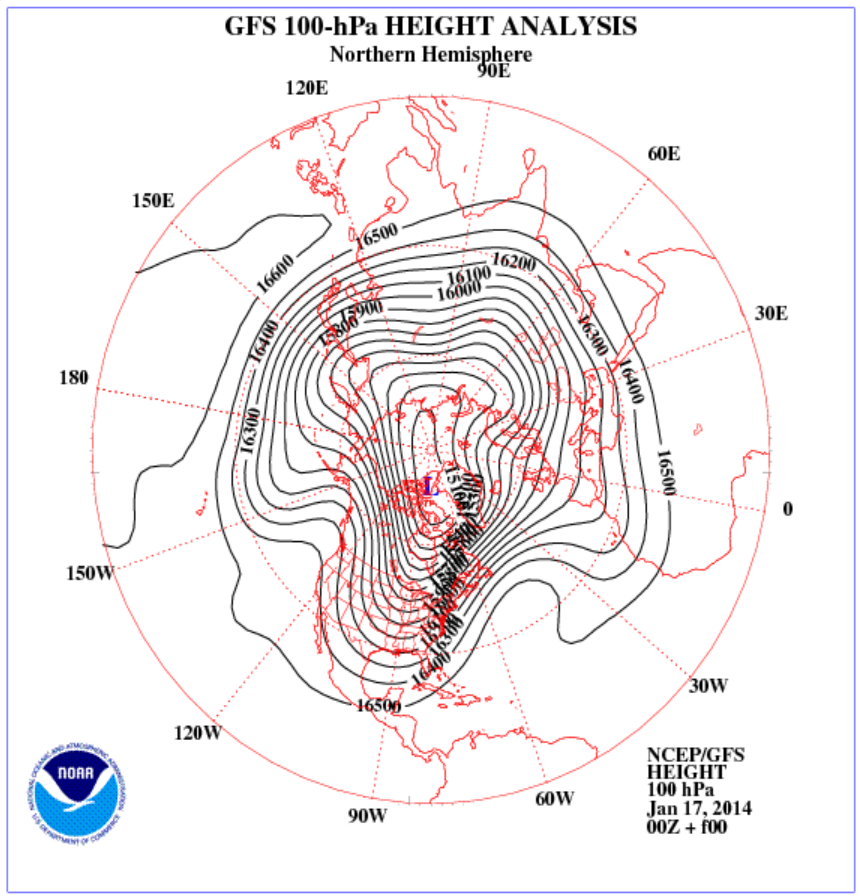


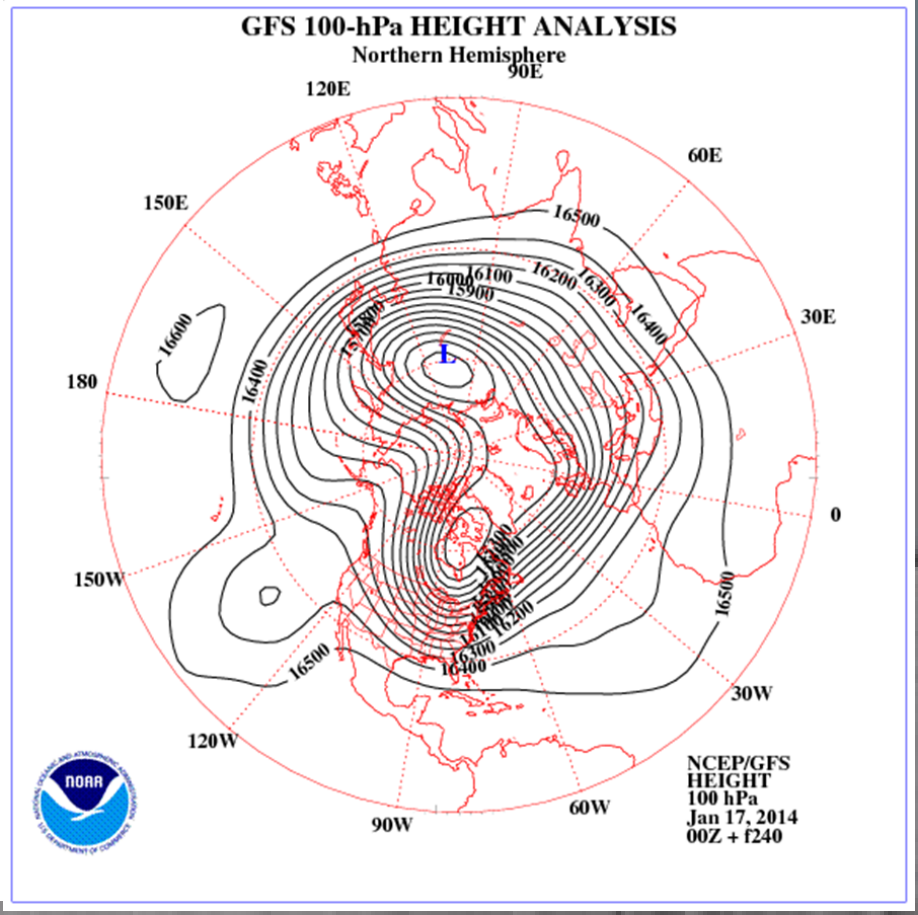
Temperature anomaly for below normal East Asian snow cover puts Southwest Michigan around 1.5 degrees above normal.

Polar Vortex Splitting….
Sudden Stratospheric Warming

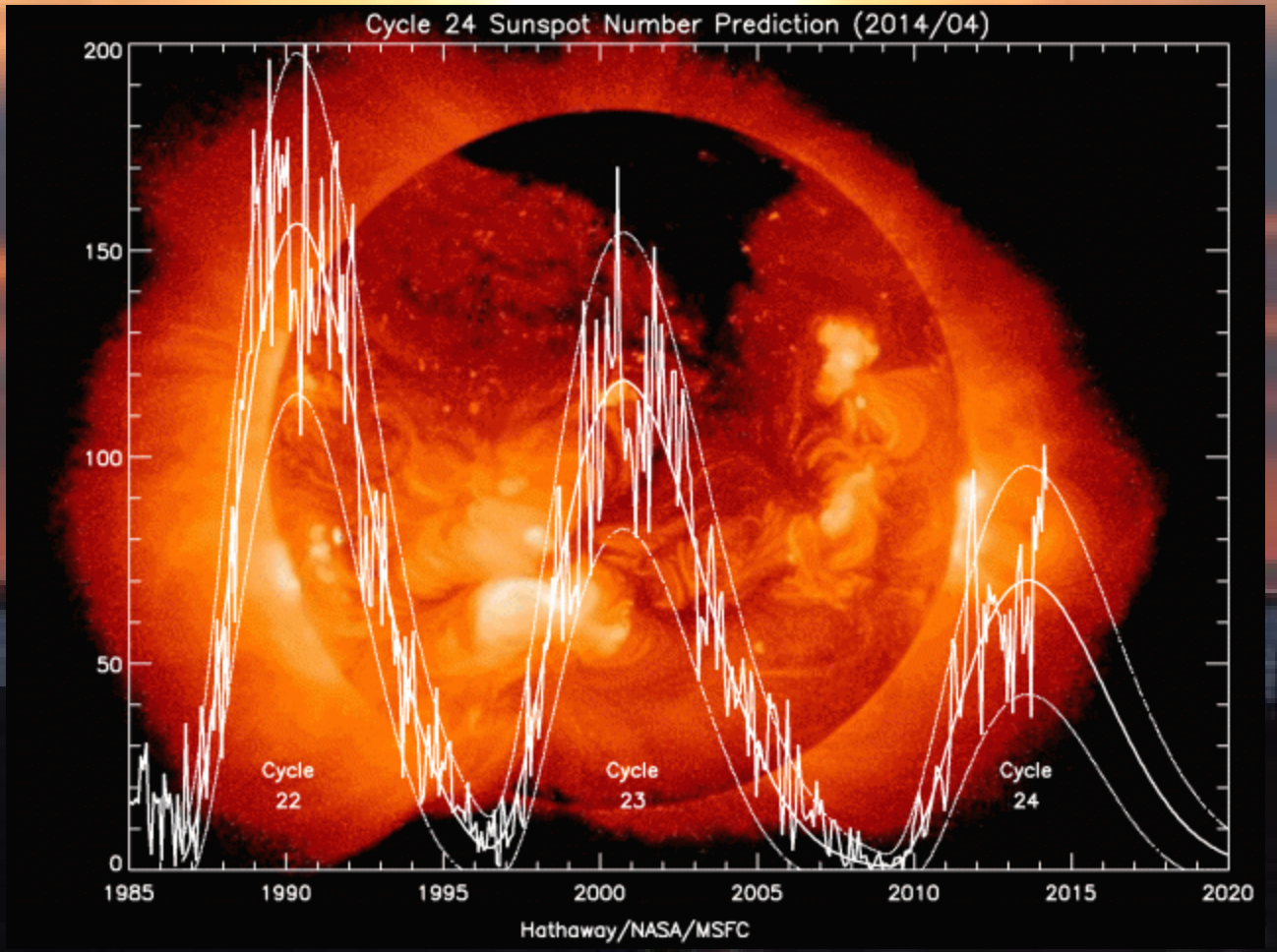


Polar Vortex Splitting…. Sudden Stratospheric Warming





Sunspot Cycle trend …..
Cooler Weather Ahead



Sunspot Cycle trend …..
Cooler Weather Ahead